CLAIMS

What is claimed is:

1. A method for designing a layered structure on a substrate, comprising:

providing a layered structure comprising at least one dielectric layer over a substrate and parallel line features embedded in the dielectric layer;

using analytical expressions to compute stresses in a line feature from curvature information of the substrate in an area of the line feature, local temperature information, geometry information of the line feature, the dielectric layer, and the substrate and material information of the line feature, the dielectric layer and the substrate;

using computed stresses to determine whether a stress-induced failure condition is met;

adjusting a parameter of the layered structure if the stress-induced failure condition is met;

using the analytical expressions to compute stresses in the line feature based on the adjusted parameter; and

continuing to adjust the parameter until the stress-induced failure condition is not met.

2. The method as in claim 1, wherein the parameter is a geometry parameter.

3. The method as in claim 1, wherein the parameter is a material property of one of the line feature, the dielectric layer, and the substrate.

4. The method as in claim 1, wherein the parameter is a temperature under which a device made from the layered structure operates in normal operations.

5. The method as in claim 1, wherein the parameter is a thermal budget under which the layered structure is processed during fabrication.

6. The method as in claim 1, wherein the layered structure comprises at least two dielectric layers with embedded line features and at least a vertical via that connects line features respectively in the two dielectric layers, the method further comprising:

using an analytical expression to compute a stress along the vertical via from a vertical stress of the connected line

features, local temperature information, geometry information of the line features and the via, and material information of the dielectric layer and the via;

using computed stresses to determine whether a stress-induced failure condition for the via is met;

adjusting a parameter of the layered structure if the stress-induced failure condition for the via is met;

using the analytical expressions to compute stresses in the line features based on the adjusted parameter; and

continuing to adjust the parameter until the stress-induced failure condition for the via is not met.

7. A method for fabricating a layered structure on a substrate, comprising:

processing a substrate to form at least one dielectric layer on the substrate and parallel line features embedded in the dielectric layer;

obtaining local curvature information in an area of a line feature;

obtaining local temperature information in the area of the line feature; and

using analytical expressions to compute local stresses in the line feature from the local curvature information and the

local temperature information of the line feature, geometry information of the line feature, the dielectric layer, and the substrate, and material information of the line feature, the dielectric layer and the substrate.

8. The method as in claim 7, further comprising using an optical probe beam to illuminate the layered structure and detecting optical reflection of the optical probe beam from the layered structure to obtain the local curvature information.

9. The method as in claim 8, further comprising directing the optical probe beam onto a surface of the substrate on which the dielectric layer and the parallel line features are fabricated.

10. The method as in claim 8, further comprising directing the optical probe beam onto a surface of the substrate that is opposite to a substrate surface on which the dielectric layer and the parallel line features are fabricated.

11. The method as in claim 8, further comprising using the optical reflection to further obtain curvature information of an area illuminated by the optical probe beam.

12. The method as in claim 8, further comprising using an optical shearing interferometer to optically process the optical reflection in obtaining the local curvature information.

13. The method as in claim 12, further comprising using two optical gratings in the optical shearing interferometer to perform optical shearing in optically processing of the optical reflection.

14. The method as in claim 12, wherein the optical shearing interferometer comprises a radial shearing interferometer.

15. The method as in claim 12, wherein the optical shearing interferometer comprises a bi-lateral shearing interferometer having a wedge plate.

16. The method as in claim 7, further comprising:

computing a critical value for a change in temperature according to a failure criterion of the layered structure by using the analytical expressions; and

controlling a variation in temperature during fabrication to be away from the critical value.

17. The method as in claim 7, further comprising:

computing a critical value for a change in curvature according to a failure criterion of the layered structure by using the analytical expressions; and

controlling a condition during fabrication to make a change in curvature to be away from the critical value.

18. The method as in claim 7, wherein the substrate comprises at least another dielectric layers with embedded line features on the dielectric layer and at least a vertical via that connects line features respectively in the two dielectric layers, the method further comprising:

using an analytical expression to compute a stress along the vertical via from a vertical stress of the connected line features, local temperature information, geometry information of the line features and the via, and material information of the dielectric layer and the via; and

adjusting a processing condition according to the computed stress along the vertical via.

19. The method as in claim 7, further comprising adjusting a processing condition according to the computed local stresses.

20. A system, comprising:

a substrate holder to hold a substrate fabricated with a dielectric layer and parallel line features embedded in the dielectric layer;

a sensing module to interact with the substrate to obtain information about a temperature and curvatures of a line feature on the substrate; and

a processing module programmed with analytical expressions to compute local stresses in the line feature from curvature and temperature information of an area having the line feature, geometry information of the line feature, the dielectric layer, and the substrate, and material information of the line feature, the dielectric layer and the substrate.

21. The system as in claim 20, wherein the sensing module comprises an optical shearing interferometer system that projects a probe light beam to the substrate to measure curvatures of the line feature.

22. The system as in claim 21, wherein the optical shearing interferometer system comprises a CGS system.

23. The system as in claim 21, wherein the optical shearing interferometer system comprises a radial shear interferometer.

24. The system as in claim 21, wherein the optical shearing interferometer system comprises a bi-lateral sharing interferometer that comprises a wedge plate which performs optical shearing.

25. The system as in claim 20, wherein the layered structure comprises at least two dielectric layers with embedded line features and at least a vertical via that connects line features respectively in the two dielectric layers, and

wherein the processing module is further programmed to use an analytical expression to compute a stress along the vertical via from a vertical stress of the connected line features, local temperature information, geometry information of the line features and the via, and material information of the dielectric layer and the via.

26. The system as in claim 25, wherein the layered structure comprises a capping layer on top of embedded line features and an adjacent top layer, wherein the processing

module is programmed to include effects of the capping layer in the analytical expression.

27. A method, comprising:

providing a layered structure comprises a plurality of layers stacked over one another and each having embedded line features;

optically obtaining information on a surface of the layered structure;

processing the optically obtained information to extract curvature information of the surface; and

applying analytical expressions to compute local stresses in a line feature based on extracted curvature information and a local temperature at a location of the line feature.

28. The method as in claim 27, wherein the layered structure comprises at least one vertical via that connects line features respectively in two different dielectric layers, the method further comprising:

using an analytical expression to compute a stress along the vertical via from a vertical stress of the connected line features, local temperature information, geometry information of

the line features and the via, and material information of the connected layers and the via.

29. The method as in claim 27, wherein the information on the surface is optically obtained by:

illuminating a probe beam to the surface to generate a signal beam carrying the information on the surface;

using an optical shearing interferometer to optically process the signal beam to produce a shearing interference pattern; and

using the shearing interference pattern to extract the curvature information.

30. The method as in claim 27, further comprising using a gradient sensing system having two optical gratings as the optical shearing interferometer to produce the shearing interference pattern.

31. The method as in claim 27, wherein the layered structure comprises at least one vertical via that connects line features in two different layers, the method further comprising:

using an analytical expression to compute a stress along the vertical via from a vertical stress of the connected line

features, local temperature information, geometry information of the line features and the via, and material information of materials of the layers and the via.